

Project Report

Machine Learning Project 1

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Project Name: Iris Pupil Diameter Analytics & Anomaly Prediction System

Iris Pupil Diameter Analytics & Anomaly Prediction – Detailed Description

Iris Pupil Diameter Analytics & Anomaly Prediction is a machine learning application that monitors and analyzes pupil diameter variations to detect anomalies. Variations in pupil size can indicate physiological responses, emotional changes, fatigue, or early signs of neurological disorders. The system uses machine learning to analyze data and predict abnormal behavior, helping researchers, healthcare professionals, and HCI systems to gain insights into eye dynamics.

1. Problem Overview

Pupil diameter varies across individuals due to:

- Light exposure
- Emotional and cognitive states
- Health conditions
- Neurological or ophthalmic disorders

Manual monitoring of pupil diameter is time-consuming and prone to errors. Machine learning-based analytics provide an efficient, data-driven way to detect abnormal pupil behavior and track trends over time.

2. Objective

The primary objective is to analyze pupil diameter dynamics and predict anomalies using historical data and machine learning techniques.

Input: Eye-tracking dataset or real-time pupil diameter measurements

Output:

- Pupil diameter analytics (mean, variance, trends)

- Anomaly detection alerts for abnormal pupil behavior
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3. Dataset Description

A commonly used dataset contains the following features:

Feature	Description
timestamp	Time of measurement
pupil_diameter	Measured pupil diameter (in mm)
light_level	Ambient light intensity
emotional_state	Optional: Recorded emotional or cognitive state
user_id	Identifier for individual subjects

Target Variable: Anomalous pupil behavior (binary or flagged instances)

4. Data Preprocessing

Before model training, the dataset undergoes preprocessing:

- A. Handling missing or inconsistent pupil measurements
- B. Feature engineering:

- Normalization of pupil diameter
- Encoding categorical features like emotional state
- C. Splitting the dataset:
 - 80% training data
 - 20% testing data

5. Machine Learning Models Used

Several models can be applied for analytics and anomaly detection:

a. Linear Regression / Time-Series Models

- To model normal pupil diameter trends over time
- Captures gradual variations

b. Isolation Forest / One-Class SVM

- Detects anomalies in pupil diameter patterns

- Flags sudden abnormal dilations or constrictions

c. LSTM (Long Short-Term Memory)

- Captures temporal dependencies in pupil dynamics
 - Predicts future pupil diameters and detects deviations
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6. Results and Insights

Key findings from the trained models:

- Sudden dilations or constrictions can indicate abnormal conditions
 - Light level and emotional state significantly influence pupil diameter
 - The model can detect anomalies with high accuracy, improving early intervention potential
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7. Applications

- **Healthcare and Neurology:** Early detection of eye or neurological disorders
 - **Human-Computer Interaction (HCI):** Systems adapt to user focus or cognitive load
 - **Behavioral Research:** Studying stress, attention, and emotional responses
 - **Security & Biometrics:** Enhanced iris-based authentication with anomaly monitoring
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8. Deployment

The trained models can be deployed using:

- **Streamlit or Flask Web App:** Users input data or use real-time eye-tracking devices
→ System analyzes and predicts pupil anomalies
 - **Interactive Dashboard:** Visualizes pupil diameter trends, highlights anomalies, and generates alerts
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Conclusion

The **Iris Pupil Diameter Analytics & Anomaly Prediction System** demonstrates the effective use of machine learning to monitor physiological signals. It enables real-time analysis, anomaly detection, and predictive modeling, enhancing research, clinical, and human-computer interaction applications. By providing data-driven insights, the system improves understanding of pupil dynamics and supports early interventions for abnormal behavior.